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SOLAR PHYSICS COMMITTEE.

AREAS OF CALCIUM FLOCCULI ON SPECTROHELIOGRAMS.

1906-1908.

LONDON:
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SOLAR PHYSICS COMMITTEE.

AREAS OF CALCIUM FLOCCULI ON SPECTROHELIOGRAMS,

1906-1908.

Measured and Reduced at the Solar Physics Observatory, South Kensington.

UNDER THE DIRECTION OF

Sir NORMAN LOCKYER, K.C.B., LL.D., D.Sc., F.R.S.

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MEASUREMENTS OF SOLAR FLOCCULI, CHIEFLY FROM SPECTROHELIOGRAMS OBTAINED AT KODAIKANAL, SOUTH INDIA, SUPPLEMENTED BY OTHERS TAKEN AT SOUTH KENSINGTON AND MEUDON.

1906–1908.

From a preliminary discussion on the sources from which daily spectroheliograms of the sun's disc could be obtained, five were selected as supplying series suitable for measurement, viz., Kodaikanal, South Kensington, Meudon, Tortosa, and Mount Wilson.

By arrangement with the Director General of Observatories, India, negative or positive records of the flocculi taken at Kodaikanal have been received from the beginning of 1906. After the preliminary examination of records from other stations, it was found that the differences of scale and general definition introduced difficulties of comparison, and the general completeness of the Kodaikanal record throughout the greater part of the year suggested its being taken as the chief basis for the investigation. A few of the gaps in the Indian record were filled in from the South Kensington series, the plates of which are nearly on the same scale, and until other difficulties came to be introduced, provision was made to utilise measurements of spectroheliograms from Meudon and Mount Wilson.

A number of plates for July 1906 from Kodaikanal and South Kensington were measured independently, and the result indicated that such measures from S.K. plates could be incorporated with those from K.Kl. by a simple adjustment factor for area.

METHOD OF MEASUREMENT.

In selecting a method of measuring the areas of flocculi one of the chief points on which some difficulty was experienced was due to the comparatively indefinite contours of the boundaries of the flocculi.

This introduced an uncertainty into the measurements owing to different observers including different extents of the indefinite boundaries; this in the case of such large areas made large differences in the results by different observers for the same flocculi.

Various methods were tried to minimise this difficulty, and a description of these preliminary results was communicated to the Solar Union Conference held at Meudon in 1907.

The general conclusion was that the most consistent measurements were obtained by employing a glass reseau, ruled with crossed lines $\frac{1}{100}$th of an inch apart, held in close contact with the negative and examined with a low power hand magnifier.

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For convenience in counting the number of squares, every fifth line is thickened, giving larger squares of 25 units. This system has been employed for many years past in the measurement of sunspot areas, but the features are in that case of much less magnitude, and therefore the relative error in estimating the boundary is correspondingly lessened.

GENERAL TYPES OF FLOCCULI.

The general aspect of the spectroheliograms consists of (*a*) a surface mottling caused by a fine network of radiating material extending almost uniformly over the whole solar surface; (*b*) the concentrated flocculi masses, usually occurring in well-defined belts more or less parallel to the solar equator, and practically identical with the sunspot zones.

Attention has been confined to the features of this latter class, and as they are frequently of extremely irregular form and very much broken up, it became necessary to devise some means of recording which parts were selected for measurement.

INDEX PRINTS FOR REFERENCE.

This was conveniently done by making index prints from the original negatives, and then enclosing each measureable mass by an inkmark with a reference number, keeping the flocculi separated for the two hemispheres.

FORESHORTENING NEAR THE LIMB.

On considering the question of foreshortening near the limb, it was decided to neglect any flocculi outside a zone occupying an angular opening of 60° from the centre, and treat the other masses within such zone as if on a plane surface. This involves little more error than is involved in the rough nature of the measurements, and exact determinations of any of the flocculi areas may readily be obtained at any subsequent time by reference to the numbered index prints.

All the measurements have been made independently by two observers, and the reductions have been duplicated.

REDUCTION TO UNIFORM SCALE.

In consequence of the fact that the diameter of the solar image at any station is variable throughout the year, the measurements are reduced to a uniform scale for intercomparison, the unit being the millionth part of the sun's visible projected hemisphere. This system also allows of the inclusion of data from separate stations with solar images of different diameters.

To obtain the mean diameter for the month three plates have been selected, taken near the beginning, middle and end of each month, and the vertical and horizontal diameters measured in each case. The mean of these six values is taken as the mean monthly diameter.

From this by a simple proportion the value of one square of the reseau is determined in millionths of the hemisphere. This is then used as a factor applied to all the measures of the areas of flocculi for the month.

SPECTROHELIOGRAMS FROM OTHER SOURCES.

A few spectroheliograms for some of the days on which no records have been obtained at Kodaikanal or South Kensington have been received from Mount Wilson and Mendon. These were reduced to the Kodaikanal scale and trial measurements made on them.

On account of the great difference in scale, and the greater amount of detail generally shown on these larger images, it was found difficult to get a satisfactory comparison with the results from the smaller plates. Taking this into consideration with the fact that the Kodaikanal record has itself provided for over 300 days in each of the recent years, it was decided to confine the initial measurements to the two series of Kodaikanal and South Kensington, which are nearly on the same scale and taken with instruments of similar construction.

TABLES AND CURVES OF AREAS OF FLOCCULI.

The accompanying tables give the variations of areas of flocculi for the years 1906, 1907, 1908, in millionths of the sun's projected hemisphere, arranged as the means of independent measures made by two observers.

The present report and curves have been prepared by Mr. C. P. Butler. The measurements for 1906 were made by Mr. C. P. Butler and Mr. H. E. Goodson. Those for 1907 and 1908 were made Mr. H. E. Goodson and Mr. T. F. Connolly.

NORMAN LOCKYER.

Solar Physics Observatory,
South Kensington,
March 17, 1913.

AREAS OF FLOCCULI (1906).

(In millionths of Sun's projected Hemisphere.)

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	21,790	24,810	—	48,270	27,120	15,930	40,860	—	11,540	—	10,410	—
2	22,570	24,400	10,200	30,990	32,660	30,880	61,500	23,980	20,270	24,060	—	13.430
3	21,920	24,770	7,970	36,530	—	21,120	46.720	30,140	14,290	17,640	—	27,050
4	15,310	31,600	15,850	38,420	20,500	23,220	48.840	12,360	9,964	26,240	—	24,630
5	—	22.490	11,150	32,610	13,950	33,200	47,580	12,820	—	18,200	8,213	—
6	—	16,970	22,880	33,080	22,190	26,330	—	6,217	24,620	12,530	—	—
7	21,050	28,800	28,590	28,290	22,530	38,710	25,050	4,888	27,030	18,080	—	—
8	14,530	28,240	32,960	21,100	30,200	35,840	32,090	—	34,350	9,640	—	—
9	14,070	42,640	20,080	27,220	37,900	—	26,870	11,180	21,490	12,410	—	—
10	18,480	38,660	30,700	27,300	—	40,740	15,850	—	28.460	15,500	—	—
11	37,850	30,890	33,690	30,990	23.710	24,270	23,310	10,720	28,350	14,810	—	18,770
12	23,460	30,080	20,550	32,490	32,560	—	18,550	15,440	24,160	11,000	—	21,870
13	22,570	25,640	21,280	30,300	33,430	—	24,410	23,830	20,340	13,590	—	13.430
14	10,950	23,710	15,330	21,320	40,560	—	—	16,110	16,230	10,040	—	20,610
15	22,270	—	28,850	35,180	36,690	—	—	17,810	17,230	22,030	—	19,570
16	—	—	22,080	34,630	37,160	—	—	23,930	15,870	7,381	—	20,720
17	—	—	—	38,920	27,290	—	—	18,870	21,410	—	—	—
18	—	15,480	—	34,010	35.580	—	—	—	—	—	—	—
19	16,730	25,420	35,060	44,750	28,710	—	—	—	—	—	9,366	—
20	21,330	29,300	29,740	44,920	44,230	—	—	—	—	—	—	—
21	—	22,050	58,590	37,940	27,480	23,790	--	—	—	—	—	—
22	23,830	39,300	67,670	—	31,110	—	—	—	—	—	—	—
23	30,350	—	64,820	46,500	34,660	16.540	29.640	—	—	16,320	18,370	—
24	20,910	33,640	70,310	38,750	33.940	28,360	24,320	—	—	—	—	—
25	42,310	—	68,100	31,390	34,370	—	24,390	—	—	—	—	—
26	26,900	23,070	69,700	—	37,980	19,790	32,140	—	14,840	—	19,570	—
27	45,290	16,470	54,420	32,530	38,020	20,090	—	—	8,460	—	14.030	—
28	39,550	—	41.030	32,370	37,780	24,130	29,050	—	8,986	—	14,440	—
29	37,880		29,730	—	—	—	—	21,650	10,750	26,280	12,760	—
30	26,740		41,690	24,910	27,260	42,330	19,700	23,420	11,570	23,250	15,690	—
31	29,040		52,010		30,480		—	11,710		13,520		—

AREAS OF FLOCCULI (1907).

(In millionths of Sun's projected Hemisphere.)

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	—	55,160	27,390	32,040	31,770	31,090	—	22.300	18,720	37,350	11,920	5,400
2	—	44,350	47,450	—	22,470	33.430	16.410	27.260	35.520	27,940	10,830	11,680
3	—	25,950	45,740	—	21,130	46.850	16.990	14.160	34,820	18,750	12.920	27.370
4	—	40,060	34,060	43,990	41,990	36,400	17.540	13.640	37.010	25.000	—	26,650
5	—	31,800	49,350	33,390	25.220	28,860	17,540	15.980	33.960	38,300	—	31,750
6	—	45.810	59,940	35,640	38,630	21,510	15,810	19,790	40,720	38,390	—	34,470
7	—	44,240	47,970	33,650	29,050	32.640	13,420	13.220	36,320	31,150	23.770	39,500
8	—	47.400	52.830	43.810	26,020	33,330	14,160	—	31,580	28,130	—	57.460
9	—	48,150	61,860	43,760	35,510	24,880	13.830	15,180	40,720	27,430	29,630	48,210
10	—	56,570	41,650	29,370	31,650	7,380	12,130	15.250	36,270	21,490	—	45,220
11	—	48,430	41,300	20,930	39,080	—	21.460	—	37,080	31,400	33,670	47,120
12	—	47,510	34.870	29,550	34,650	21,550	22.750	—	33.350	38,990	35,110	46,440
13	—	51,180	34,570	23,950	30,390	—	16,820	31.220	27,180	24,280	31,820	34,610
14	—	40.780	25,110	26,860	25,690	19.660	28,060	20,500	28.020	33,520	37,870	47,700
15	—	32,230	21.180	17,390	16,150	—	30.520	14,960	21,050	36,280	45.150	49,030
16	—	27,840	29,940	10,950	17.910	21,840	26.770	25,640	29,970	34,540	38.530	—
17	—	20,310	15,180	21,300	15,990	30,390	26,700	15,860	31.230	38,160	—	—
18	—	30.280	26,190	11,950	21,740	—	19,540	16,740	27,500	41,200	34.170	—
19	—	20,810	36,540	14,770	23.770	31,360	25,080	20,050	29,650	42.220	27,380	29.110
20	—	23,950	23,050	23,480	17,030	31,180	21,310	27,700	49.230	36,720	29,680	22.400
21	—	26,770	29.460	15,650	22,640	26,660	—	22.140	33,940	41,090	23,450	21,780
22	—	38,530	26.220	22,860	19,280	23,930	—	30,590	26,960	37,370	42,670	16,820
23	—	41,320	25,280	21,910	27,510	17,790	—	17,780	40,020	38,200	12,600	18,450
24	—	36.070	22,400	22,810	18,760	25,510	13,300	21,950	37,480	35,600	—	26.940
25	—	38,720	29,960	18,650	18,260	21,100	22,220	—	38,080	—	27,570	23,350
26	5,520	37,460	22,520	19,020	18,310	21,600	21,550	—	47,480	38,880	—	13,740
27	—	26,750	24,490	—	25,830	22,320	19,740	24,220	49,450	30,820	27,750	12,090
28	—	26,680	14,880	24.630	29,680	20,290	8,420	23,440	47,480	25,490	25,660	9.490
29	29,810		22,790	25,700	27,440	18,320	21,510	31,800	34,520	32,470	15.630	23.660
30	24,760		35,390	26,430	29,660	—	18,510	24,150	36,780	32.010	14,220	23.930
31	28,650		19.340		30,940		24,900	28,010		22,400		35,720

AREAS OF FLOCCULI (1908).

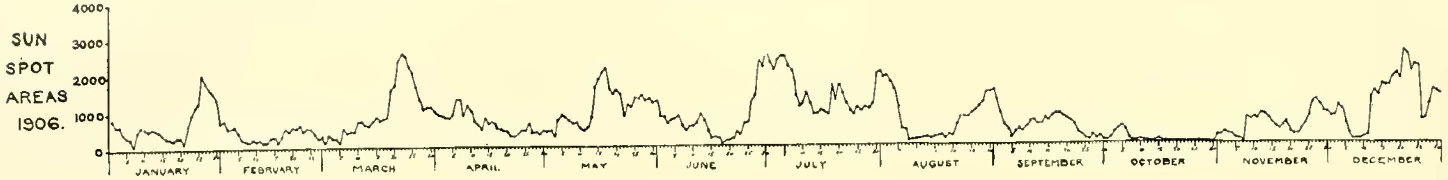
(In millionths of Sun's projected Hemisphere.)

—	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	36,910	65,440	23,750	14,410	38,920	44,640	40,720	—	48,200	27,730	—	—
2	—	69,140	28,030	18,490	42,660	34,670	40,270	20,410	56,240	26,360	—	26,390
3	44,320	51,650	33,020	23,280	45,170	42,650	34,730	—	—	33,300	—	23,760
4	43,245	69,550	27,710	19,760	41,360	63,970	28,730	—	37,140	—	26,880	21,190
5	60,457	48,960	19,940	19,820	33,880	54,260	—	32,850	30,160	32,680	32,550	27,370
6	—	47,470	22,630	40,050	33,100	56,580	34,470	—	18,650	34,700	30,520	33,060
7	54,146	45,520	32,610	40,050	24,460	52,380	29,880	—	—	22,600	27,110	34,830
8	61,107	34,360	21,620	36,540	25,520	41,480	20,250	26,250	23,900	31,510	28,110	36,100
9	64,040	25,410	27,960	43,940	34,780	35,970	24,530	27,220	23,970	35,270	32,030	32,080
10	59,764	33,530	28,510	38,410	33,450	25,520	15,880	22,460	28,070	39,210	32,620	29,670
11	54,280	32,190	29,170	29,470	30,400	—	—	21,630	22,470	24,380	34,540	22,080
12	44,386	35,930	24,460	33,530	27,800	17,200	—	11,480	38,070	22,330	27,880	30,010
13	28,740	27,250	30,750	22,980	23,630	—	13,970	19,200	29,810	25,260	27,790	27,150
14	51,147	35,020	34,460	24,380	21,710	—	7,190	21,720	27,810	18,500	21,810	26,010
15	39,149	41,870	28,510	23,560	25,900	16,750	6,880	25,670	27,760	15,750	24,700	27,470
16	29,099	40,190	15,710	30,120	20,270	9,670	15,740	30,490	20,690	23,310	32,210	14,700
17	22,697	31,030	23,400	20,410	25,760	14,970	23,430	28,700	27,720	21,090	28,490	35,200
18	23,592	28,490	29,450	25,870	26,780	19,740	22,330	31,870	27,670	15,770	34,700	36,070
19	19,428	23,620	28,620	24,100	16,460	25,750	—	3,330	33,460	22,550	36,390	30,720
20	29,612	24,140	32,400	29,770	18,910	22,430	—	29,980	23,940	28,900	42,320	17,670
21	32,837	23,510	23,400	25,500	20,450	30,880	—	25,910	35,570	19,800	42,910	25,590
22	32,344	33,870	—	28,300	15,390	35,200	26,340	3,330	37,200	—	28,760	26,150
23	32,725	22,960	24,980	18,330	22,420	—	—	25,080	37,160	—	33,660	22,760
24	23,458	—	19,830	31,080	19,130	—	29,500	28,820	36,110	—	26,680	16,000
25	35,881	—	22,420	29,380	17,330	29,740	31,000	8,810	51,670	—	14,490	16,530
26	37,582	—	17,180	25,870	24,170	34,360	—	15,100	52,980	34,100	20,180	18,480
27	28,160	17,070	11,910	36,870	24,100	34,090	—	27,960	43,090	35,520	—	23,940
28	40,313	34,030	17,270	37,600	25,590	—	21,760	42,890	42,850	—	20,470	16,530
29	18,469	21,830	22,650	35,720	34,730	33,880	34,220	47,090	38,260	—	20,180	16,240
30	29,993		13,070	39,860	25,740	34,400	—	51,950	42,100	15,420	20,930	22,670
31	48,034		29,950		34,310		31,000	54,090		20,540		—

VARIATIONS OF AREAS OF SUN-SPOTS AND FLOCCULI.

1906—1908.

1.



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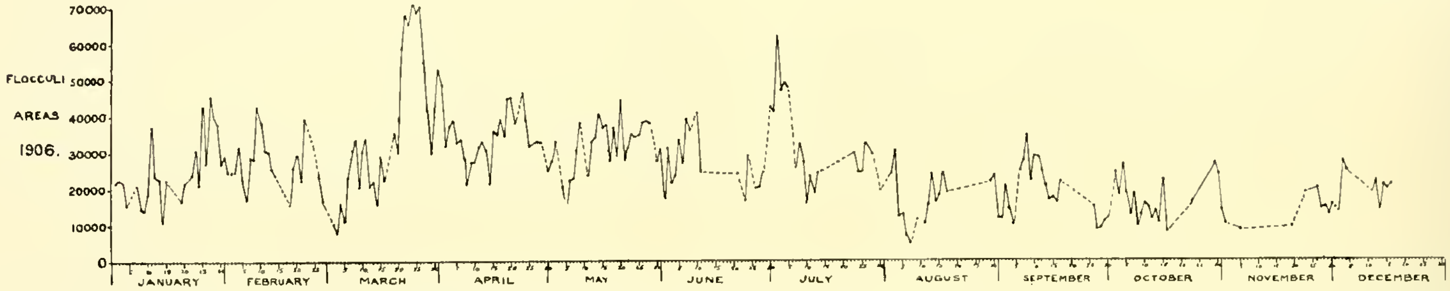

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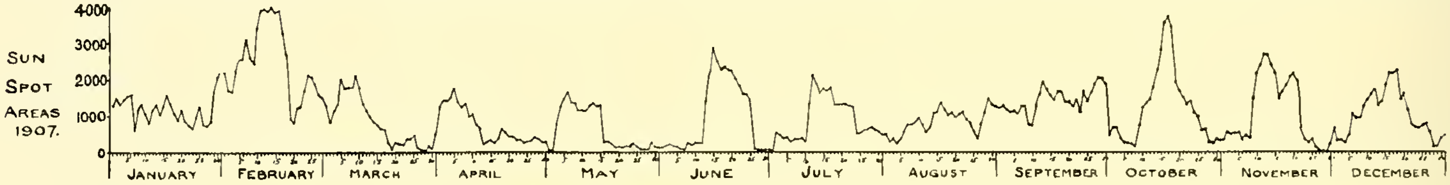

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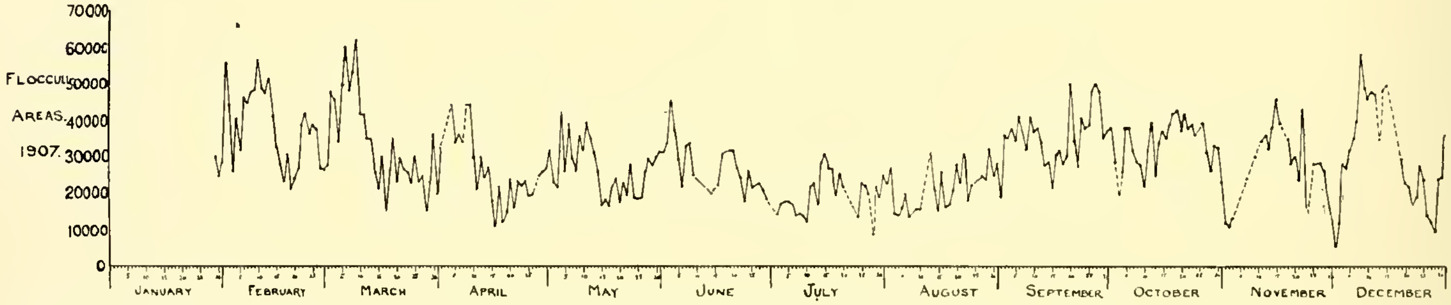

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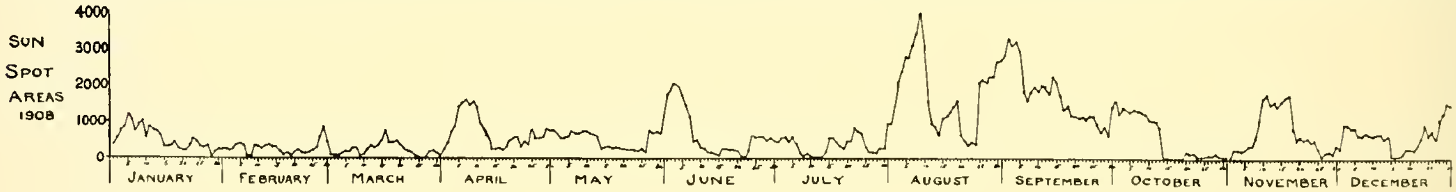

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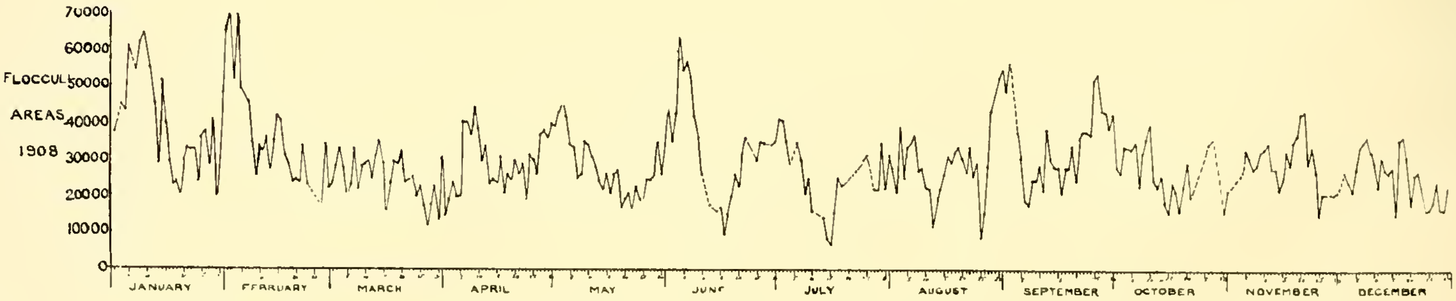

DESCRIPTION OF PLATE.

Curve 1—Variation of Areas of Sunspots - - -	(1906.)
,, 2 ,, ,, ,, Flocculi - - -	
,, 3 ,, ,, ,, Sunspots - - -	(1907.)
,, 4 ,, ,, ,, Flocculi - - -	
,, 5 ,, ,, ,, Sunspots - - -	(1908.)
,, 6 ,, ,, ,, Flocculi - - -	

Areas of Sunspots.—These represent the Greenwich measures from photoheliograms taken at Greenwich, Dehrà Dûn, Kodaikanal and Mauritius.

Areas of Flocculi.—These represent the means of independent measures made by two observers at South Kensington from spectroheliograms taken at Kodaikanal and South Kensington.

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